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ABSTRACT

Explanations for memory development have tended to focus on acquistion of general strategies and metaknowledge. Recently, emphasis has been given to the knowledge base as a whole, including general world-knowledge and domain-specific knowledge and procedures. Evidence is presented from the memory development literature showing why strategies and metaknowledge, although undoubtedly important in development, are not sufficient factors to account for memory development, especially if considered in isolation. Current research on the influence of the general knowledge base and the kinds of questions that must be considered by further research are summarized. (Author)

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CHANGING CONCEPTION OF SOURCES OF MEMORY DEVELOPMENT

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Changing Conception of Sources of Memory Development

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Abstract. Explanations for memory development have tended to focus on acquisition of general strategies and metaknowledge. Recently, emphasis has been given to the knowledge base as a whole, including general world-knowledge and domain-specific knowledge and procedures. Evidence is presented from the memory development literature showing why strategies and metaknowledge, although undoubtedly important in development, are not sufficient factors to account for memory development, especially if considered in isolation. Current research on the influence of the general knowledge base and the kinds of questions that must be considered by future research are summarized.

The goal of this article is to interpret the shift in memory developmental research from an emphasis on the development of strategies or control processes to the development of knowledge. This shift is apparent from examination of a recently edited volume on *Trends in Memory Development Research* [*Chi*, 1983]. One facet of this shift is a focus on content knowledge as well as general world-knowledge, as exemplified by some of my own work in memory [*Chi and Koeske*, 1983], as well as by work in other areas such as comprehension [*Pearson* et al., 1979]. Another facet is the inclusion of both strategies and metamnemonics as parts of the knowledge base. This latter change is subtle. Although it sometimes adds more confusion than clarity (for example, there is now an extensive taxonomy of different kinds of knowledge, such as knowledge about person, task, and strategy variables [*Flavell and Wellman*, 1977] and knowledge about when one knows and what one needs to know [*Brown*, 1978], it nevertheless forces investigators to be more concerned with the representation of that knowledge. That is, when one thinks of a strategy such as rehearsal simply as a form of skill, then one tends to be concerned only about issues such as when a child acquires it, when the child can use it, how generalizable it is, and how transferable it is. However, as soon as strategies are considered a form of knowledge, then one is forced to become concerned with issues such as how it is represented [*Chi*, 1984; *Nelson* et al., 1983], how it interacts with content knowledge [*Chi*, in

press; *Naus and Ornstein*, 1983], and the conditions under which it can be applied [*Paris* et al., 1983] and accessed [*Brown*, 1982]. Thus, the consideration of strategies and metamnemonics as different forms of knowledge is definitely a worthy shift, even though initially there may be confusion and vagueness with respect to definition, measurement, taxonomy, and so on.

The main question in memory developmental research is what accounts for development. For instance, if one uses recall as a dependent measure, the question becomes why the recall of older children is quantitatively as well as qualitatively different from that of younger children. Both the quantitative and qualitative differences have been attributed to three possible factors: strategies, metamemory, and content knowledge. We will review each in turn to see how and why there has been this shift in research.

Strategies

A strategy, as the term is used in the developmental literature, is a procedure, which might be represented as a rule or set of rules, which is relatively non-specific. That is, it can be applied in a variety of situations and perhaps across several domains. For example, rehearsal is a strategy that can be applied to digits, words, nonsense syllables, and so on. In the context of memory research, the number of strategies that have been identified as useful has been limited: elaboration, rehearsal, grouping or categorization, and alphabetization, to name a few.

In the seventies, the attention given to the use of strategies as a major source of developmental differences reflects the theoretical bias of the decade, during which multi-store models with control processes were popular [*Atkinson and Shiffrin*, 1968]. The question to ask was whether children were deficient in the use of control processes, and the evidence overwhelmingly supported such a claim. Because deficiencies in strategy usage have been easily identified, and since such deficiencies do correlate with performance, strategy development has been postulated as a basic source of cognitive development [*Belmont and Butterfield*, 1971; *Flavell*, 1970; *Kail and Hagen*, 1977].

This strategy development hypothesis assumes that the child fails to bring to bear some important and useful strategy (a failure known as production deficiency). Failure implies that the child must seek and use a strategy deliberately. For example, *Ornstein and Naus* [1978] referred to rehearsal as 'a member of a group of memorization processes which are available to children in the context of deliberate memory tasks' (p. 69). Failure to use a strategy is often interpreted as a faulty characteristic of the child, as if the child is unaware of the need to use a strategy (thus leading to the research on metamemory).

Let us take a closer look at the historical rationale for proposing that strategy development is an underlying source of development, by examining the kind of data used to draw such a conclusion. One implication of the strategy development hypothesis is that when one obtains performance differences between age groups, then one should presumably see underlying strategy differences. This observation is almost universally true, and led the majority of the participants in *Flavell's* [1971] landmark symposium at the meeting of the Society for Research in Child Development to conclude that strategy usage is what develops [*Chi*, 1983]. In the case of rehearsal, which is a prime example of strat-

egy usage, data in support of this assumption appear in *Belmont and Butterfield* [1971] and more recently in *Ornstein and Naus* [1978]. That is, children with poor memory performance are less likely to use a strategy, or else they do not use the adult, fully developed, form of the strategy, compared with children who perform well. The implication was that strategy usage is necessary for competent performance.

The problem with that interpretation, however, is that children's memory performance did not necessarily improve when strategies were provided for them. For example, since it was found that older children and adults group incoming stimuli into sets of three's, then one would predict that grouping the stimuli for younger children would facilitate their recall. The fact that this facilitation did not overcome age differences [*Huttenlocker and Burke*, 1976] suggested that children's inferior recall performance could possibly not be attributable to the absence of a simple strategy. At least this appears to be the conclusion from the straightforward way in which researchers have tried to simulate the use of a strategy. This unexpected outcome, that is, the inability to find a facilitating effect of providing grouped stimuli [*Huttenlocker and Burke*, 1976], is further complicated by studies which found age differences in recall with no apparent differences in strategy usage, as in the case with preschoolers [*Myers and Perlmutter*, 1978].

Hence, the increasing use of strategies with development seemed by itself to be an inadequate explanation for memory development in general. A more fruitful arena of research would be to seek the representations of strategies at different stages of development, and to understand the conditions under which they change, the conditions under which they can be elicited, how they interact with content knowledge, and how they can become less context-specific. Representative works taking these new directions are those by *Naus and Ornstein* [1983], *Siegler and Robinson* [1981], and *Chi* [in press], among others.

Metamemory

An alternative route to improving children's memory performance is to make the child more aware of his or her failure to deliberately use mnemonic strategies. This view stems from the implicit assumption that children's failure to use strategies is a consequence of a lack of deliberate actions or conscious control. As *Brown* [1978, p. 79] puts it, 'what is of major interest is knowledge about one's own cognitions rather than the cognitions themselves ... [because] in the domain of deliberate learning and problem-solving situations, conscious executive control of the routines available to the system is the essence of intelligent activity'.

The early research on metamemory, pioneered by the work of *Flavell and Wellman* [1977] and *Brown* [1975], showed great promise because the results clearly demonstrated that younger children were less aware than older children of the need to use mnemonic strategies to cope with studying and recall demands. For example, younger children were less able than older children to plan the use of elaboration, rehearsal, or categorization strategies when faced with a set of pictures that had to be remembered [*Kreutzer* et al., 1975]. Younger children not only do not plan to use strategies to help them to remember, they also do not use them in a

task where the instruction explicitly demands later recall [*Appel* et al., 1972] as compared to an instruction which does not. Hence, metamemory research points to the interpretation that young children may lack the knowledge about when one needs to apply a strategy. That is, they cannot discriminate between conditions that require strategic behavior versus those that do not. In this sense, metamemory research has substantially increased our understanding of one aspect of young children's failure to use strategies, which seems to be independent of whether the strategies are there or not, even in some incomplete form. This is an important advance, particularly for training, because it directs our attention away from teaching the procedural aspect of knowing how to execute a strategy, and towards the more discriminating aspect of understanding the conditions under which a strategy is called for.

Complications arise, however, when inconsistencies are obtained in the data between metamemory and memory results. That is, it is sometimes the case that differences in metamemory performance are obtained, but not in memory performance, and vice versa. For example, young children were able to select for restudying the items that they had failed to recall. And yet, their recall for those items did not improve even with repeated studying, although it did for older children [*Masur* et al., 1973]. One possible interpretation is that even though the younger children knew which items had to be relearned (metaknowledge), they did not have available adequate learning strategies. In other cases, differences exist in metamemory performance, without corresponding differences in memory performance. For example, in the study by *Appel* et al. [1972], although some 7-year-olds were observed to respond differently to items that were presented with the instruction 'memorize for future recall' as opposed to the instruction 'look carefully at the items' (children named the stimuli twice as often under the 'memorize' than the 'look' instruction), their recall performance for the two instructions did not differ. The same interpretation provided above for the reverse situation can be used here as well: younger children can be planful, but they do not have available the more potent strategies (assuming that naming the items twice is a less adequate strategy).

It has been difficult to reconcile such discriminant findings: namely, the lack of a correlation between metamemory and memory performance. The primary explanation for such findings has tended to consider methodological issues. These range from a concern that metamemory research relies predominantly on verbal reports and interviews, a technique which has a built-in bias against the younger children, to concern that usually only one variable is manipulated at any one time [*Wellman*, 1983]. In one study, for example, *Wellman* et al. [1981] asked children to predict how many items they could remember by varying both the number of items presented and the amount of effort needed to remember the items. Both variables affected the prediction results.

Although these methodological criticisms are legitimate, the thrust of the problem is more conceptual in nature. An alternative explanation for the discriminant memory-metamemory finding is that the way the research has been done is too general for us to say anything specific. For example, as mentioned earlier, children's deficient memory performance can be attributed either to a strategic deficit, a metamemory deficit, or both. On the other hand, a metamemory

deficit (being unplanful, and not knowing which strategies to choose) can also be attributed to a strategic deficit, and a strategic deficit can also be attributed to a metamemory deficit. Clearly, the explanations can be circular. Until we become more explicit about what each task taps and what knowledge is needed to perform a task (here knowledge refers to either the conditions of the strategic rules or the rules themselves), we will not be able to improve our understanding of memory or metamemory.

Knowledge

The knowledge explanation for memory development differs from both the strategy and metamemory explanations in one fundamental way. In the strategy approach, the explanation for developmental differences in memory performance is that younger children lack the adequate strategies that adults possess. The metamemory approach is a second-order explanation. The explanation is that younger children do not use sophisticated memory strategies, besides the fact that these strategies may be absent. Instead of lacking the strategies altogether, children may lack knowledge of the conditions of applicability of the strategies – a symptom sometimes referred to as a problem of access. Because metamemory explanations were not intended to explain memory findings directly (they were meant to explain strategic deficiencies), it is not really surprising that often memory and metamemory performances do not correlate.

The knowledge explanation is an integration of these two explanations into one, by concentrating on the representation of strategies and domain knowledge. One could view the representation of the conditions for application of the strategic rule as constituting the declarative aspect of the knowledge, as does *Anderson* [1976]. According to such a framework, a strategic rule is applied whenever all the conditions are met [see *Chi and Rees*, 1983, for an overview of rules]. The refinement, elaboration, or generality of the conditions determine when a given rule is applicable. The more general the rule, the more likely that it will be applied often. On the other hand, the more specific the conditions, the more the rule encompasses the details of the domain knowledge and hence the more likely that a rule, if applied, will produce a fruitful outcome. The trade-off between the generality and specificity of a rule is what *Newell* [1980] has referred to as weak versus strong methods. A general rule is weak, in that it can be applied under many circumstances, and yet may not necessarily be productive. On the other hand, a general rule is also more accessible across a wide number of domains. Rehearsal may be viewed as a general but weak rule. A specific rule is strong because a great many explicit conditions have to be met before it can be applied. But, once it is applied, it will usually result in a productive outcome. These explicit conditions derive from the representations of the domain knowledge in which a rule is useful and developed.

Although general rules may be weak, they probably are evolved from the specific rules. When multiple specific conditions can be replaced by a single general category of conditions, then a general rule emerges. With such a framework, it is not surprising that general rules emerge later in development. Also, it would seem to make sense to hypothesize then that specific rules depend on the knowledge of a given domain in order for them to develop. A great deal of evidence has already

been accumulated in developmental research to show that domain knowledge per se can affect developmental performance; whether this is accomplished through the application of specific rules (acquired as a consequence of developing domain knowledge) or general rules is yet unclear. The fact that expert children (children who have acquired a great deal of domain information) can excel in memory performance only in that particular domain of knowledge suggests that they have acquired specific rules. To what extent general rules emerge from the acquisition of specific rules in a number of domains is an open and empirical question. *Chi and Rees* [1983] have suggested that these general rules do develop from acquisition of domain knowledge. Such a supposition would account for the developmental findings, given that there is a general correlation between the acquisition of knowledge and maturation.

Clearly, many questions concerning memory development have been raised by the shift from strategies and metamemory towards a focus on knowledge. Many of these questions are raised by *Trabasso* [1983]. The most important of these concerns the need to understand how domain-specific knowledge is represented. Knowing exactly how it is represented will guide us towards the nature of the representation of general and specific rules. That is, how do general rules emerge from specific rules that incorporate domain knowledge? Understanding the exact representation that a child's knowledge takes will also inform us about how that knowledge can be modified and expanded, and how misconceptions occur. The changing conception of sources of memory development appears to be promising in shedding new light on children's developing capabilities in memory and problem solving tasks.

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